

ELECTRONIC FUNDAMENTALS

SERVICE PRACTICES 22

PHONO AND RECORDER MOTORS

- 22-1. Basic Principle of Motor Action
- 22-2. Principles of Induction Motors
- 22-3. Single Phase A-C Motors
- 22-4. A-C/D-C Motors
- 22-5. Hysteresis Motors
- 22-6. Phonograph Motors
- 22-7. Repair of Phonograph Motors



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Service Practices 22

INTRODUCTION

This booklet covers the theory of operation and maintenance of various types of motors and of the drive mechanisms used to transfer power from phonograph motors to turntables. Since a number of different speeds are needed to play the different types of records available, the various methods of changing the turntable speed are also explained.

22-1. BASIC PRINCIPLE OF MOTOR ACTION

The basic principle of motor action is that if current is flowing through a wire, and that wire is placed in a magnetic field, there will be a force acting upon the wire (Fig. 22-1). The field shown is produced by permanent magnets, but the same field can be produced by electromagnets.

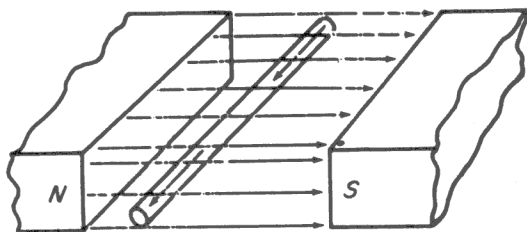
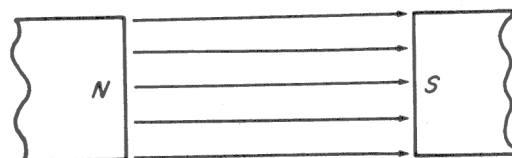


Fig. 22-1

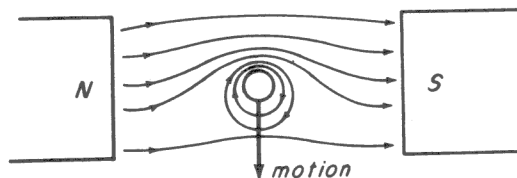
A cross section view of the magnets and the wire is shown in Fig. 22-2. The field produced by the permanent magnets alone is shown in Fig. 22-2a. The field is shown from left to right, because the direction of the magnetic field is considered to be from the north pole to the south pole. The current in the wire flows out of the paper toward you, as shown by the dot in the center of the circle representing the wire in Fig. 22-2b.



(a)



(b)



(c)

Fig. 22-2

In your lessons on electromagnetism, you learned a rule for finding the direction of the magnetic field due to the current through a wire. Point the thumb of the left hand in the direction of the current flow, and the fingers of the left hand will then point in the direction of the magnetic field. The direction of the field produced by the current through the wire is shown in Fig. 22-2b.

The combined effect of both fields is shown in Fig. 22-2c. On top of the conductor, the field of the permanent magnets and the field of the conductor are *in the same direction*. They *add* to increase the total number of lines of force on top of the conductor. Underneath the wire, the field of the wire is opposite in direction to the field of the magnets. The two fields oppose each other, and the number of lines of force underneath the wire is reduced. Above the

wire, a stronger field results; and below the wire, a weaker field is produced. The wire is forced in the direction of the weaker field. To summarize, whenever a wire carrying current is placed in a magnetic field, it will be forced toward the weaker field, and the direction of motion will be at right angles to both the direction of the current and the direction of the field.

The strength of the force acting upon the wire depends upon the length of the wire in the magnetic field, the number of wires, the strength of the magnetic field, and the amount of current flowing in the wires. An increase in any or all of these produces an increase in the force on the wire.

The fields of force around the current carrying wire and between the poles of the magnet can be used to make the wire rotate. A single-turn loop of wire is suspended in a magnetic field and pivoted so that it may be free to turn about its axis, as shown in Fig. 22-3a. Current is sent through the loop of wire by a pair of slip rings, and brushes, as shown in the figure. The current is coming out of the paper on the left side and going into the paper on the right side, as shown on the cross-sectional view in Fig. 22-3b. The total field is stronger on top of the wire on the left and underneath the wire on the right. The wire is pushed in the direction of the weaker fields. Therefore, the loop turns in a counterclockwise direction. The force that makes the wire turn is called the *torque* (tendency to rotate).

A half turn later, the loop will be in a position shown in Fig. 22-3c. The direction of current through the loop is the same as before; but since the loop has made a half turn, current is now coming out of the paper on the right side and going into the paper on the left side. As a result, the torque on the wire loop is in a clockwise direction, as shown in Fig. 22-3c. The direction of the torque is opposite to the direction of the torque when the loop was in the position shown in Fig. 22-3b. If the direction of the current through the loop is not changed, there will be equal but opposite torques on the loop every half-turn. The wire loop will turn half-way round and then return to its original position.

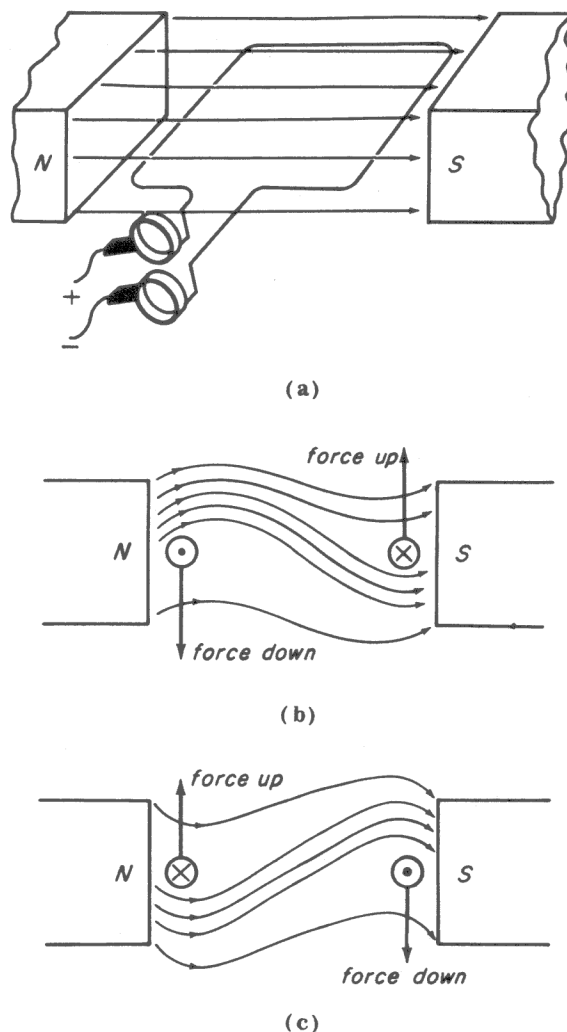
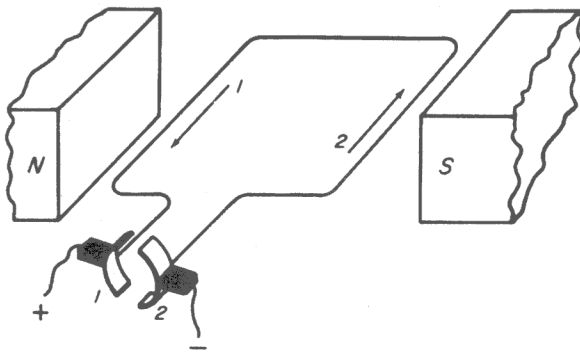


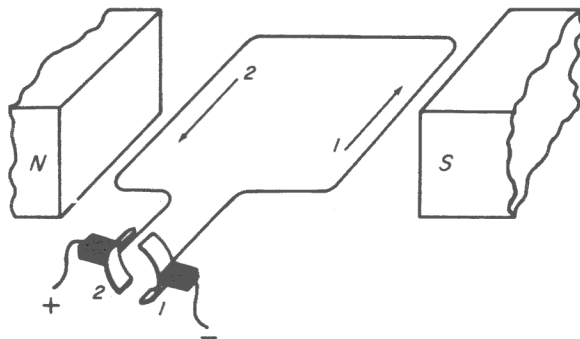
Fig. 22-3

In order to obtain continuous rotary motion — that is, to make the loop make complete turns — the direction of current through the loop must be changed with each half turn. This is done through the use of a split ring, or commutator, as shown in Fig. 22-4.

The commutator segments are attached to the loop and rotate with the loop. In Fig. 22-4a, commutator segment 1 is making contact with the positive brush, and current is flowing toward you in wire 1. The torque produced forces the loop to turn in a counterclockwise direction. A half-turn later, as shown in Fig. 22-4b, commutator segment 2 is in contact with the positive brush, and current flows toward you in wire 2. Thus, due to the action of the commutator, the current in the wire that is in front of the north pole is always toward you, and the current that is in the wire in front of the south pole



(a)



(b)

Fig. 22-4

is always away from you. Therefore, the turning force on the loop is always in the same direction.

In a practical motor, the steady field is produced by an electromagnet made up of coils of wire wound around a core of high

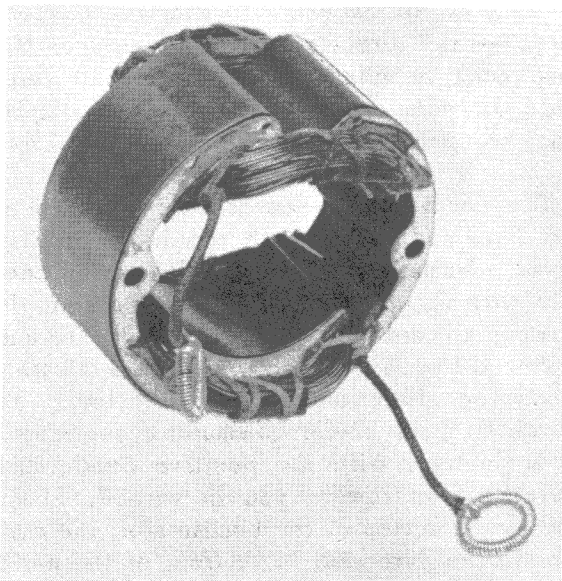


Fig. 22-5

permeability material, as shown in Fig. 22-5. This winding is called the *field*, or *stator* winding.

Instead of a single revolving loop of wire, a practical motor uses many turns of wire wound over a specially formed core of high permeability magnetic material. The conductors are brought out to a commutator for direct current, to universal ac-dc machines, or are arranged in other ways for alternating-current motors. This revolving assembly is called the *armature*, or *rotor*. A typical armature of a small universal ac-dc motor is shown in Fig. 22-6. The field and armature

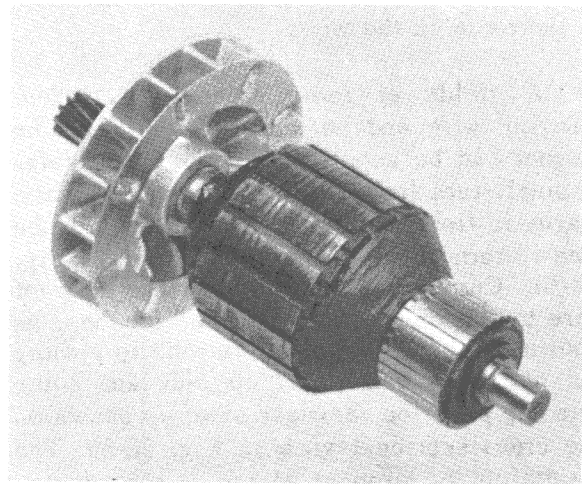


Fig. 22-6

are arranged so that the magnetic path through air is kept as short as possible as shown in Fig. 22-7.

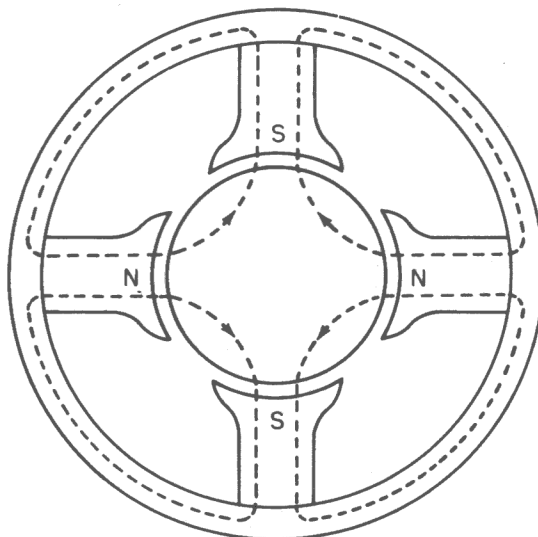


Fig. 22-7

22-2. PRINCIPLES OF INDUCTION MOTORS

If current flows through a wire that is in a steady magnetic field, a force is produced on that wire. If the magnetic field is moving, we can produce a force on the wire without sending a current through it from an external supply. Instead, the moving magnetic field induces a current in the wire, through transformer action. The induced current produces its own magnetic field. The reaction between the two fields causes a force on the wire. This is the basic principle of *induction motor* action.

If a single loop of wire, shaped as shown in Fig. 22-8, is suspended and carefully balanced so that it turns freely, and a strong horseshoe magnet is moved over one side of the loop, so that the field of the magnet cuts across the wire, the loop will move in the same direction as the magnet. If the magnet is slipped over the wire so that poles of the magnet are placed below the loop (Fig. 22-8), and pulled up over it, the loop will be forced to turn in the direction in which the magnet is pulled.

The moving magnetic field induces a current in the closed loop. The direction of this induced current is such that the magnetic field it produces acts together with the field

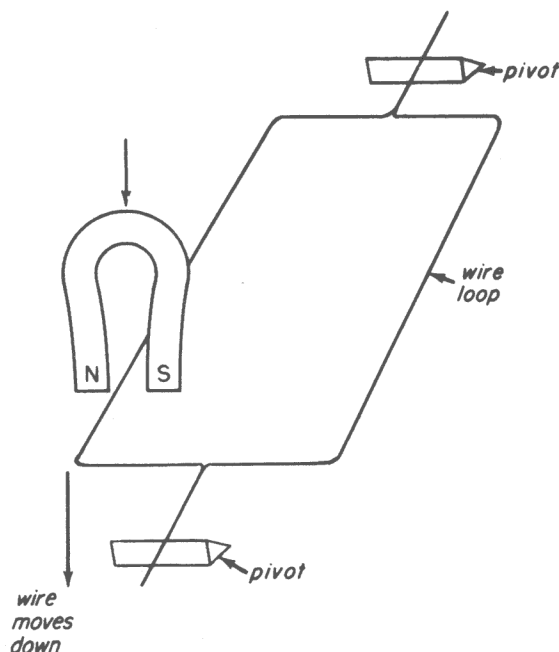


Fig. 22-8

of the permanent magnets to force the loop to follow the moving magnet.

Let us examine more closely why this happens. The first thing we have to look into is the direction of the current induced by a moving magnetic field. We know from previous lessons how to find the direction of induced currents, using the left hand rule. With the thumb and first two fingers of the left hand all at right angles to each other, point the thumb in the direction of motion of the wire, and the first finger in the direction of the flux lines. The middle finger will point in the direction of the current. Let's apply the rule to this case. A cross section of the poles of the magnet over one side of the loop is shown in Fig. 22-9. The current in the loop is counterclockwise. This current will produce a magnetic field around the wire as shown. The lines of force from the two fields will add on top of the wire and cancel on the bottom of the wire. The wire will be forced downward in the direction of the weaker field. Another way of looking at it is to recall that magnetic lines of force in the *same* direction *repel* each other, while magnetic lines of force in the *opposite* directions *attract* each other. On top of the wire, the lines of force are in the same direction and repel each other, thus forcing the wire downward; underneath the wire the magnetic lines of force are in opposite directions and attract each other, again forcing the wire downward.

In order to obtain a rotary motion, we could use a simple arrangement like that shown in

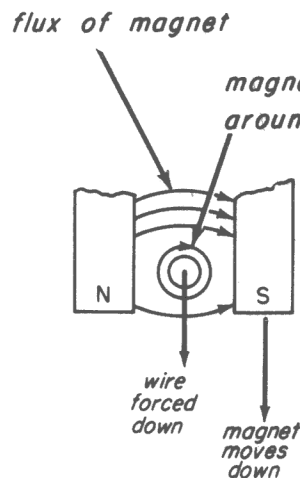


Fig. 22-9

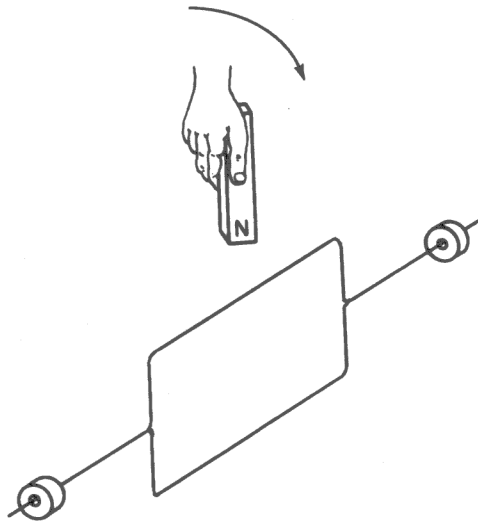


Fig. 22-10

Fig. 22-10. Suppose we move a bar magnet around the wire loop in the direction shown. The lines of the force of the rotating magnet cut the wire, and an induced current flows in the loop. The resultant field will force the loop to turn with the magnet. Note that it makes no difference whether the north or south pole of the bar magnet is used — the loop is forced in the same direction as the magnet. Note also that the speed of the loop must be slightly less than that of the revolving magnetic field. If the loop and the magnet move at the same speed, there is no cutting of lines of force, and no torque will be developed.

Producing a Rotating Magnetic Field. The method of producing a rotating magnetic field shown in Fig. 22-10 is not a practical one, because mechanical power is needed to rotate the magnets.

A rotating magnetic field can be produced electrically in a number of ways. One method is to use two separate field or stator windings that are connected to a *two-phase supply line*.

Let us represent the winding of an a-c generator shown in Fig. 22-11a. From previous lessons, you know that this winding will produce a sine-wave output, as shown in the figure. This is called a *single-phase alternating current*. Now let us add another winding, as shown in Fig. 22-11b. This winding is placed on the rotor of the genera-

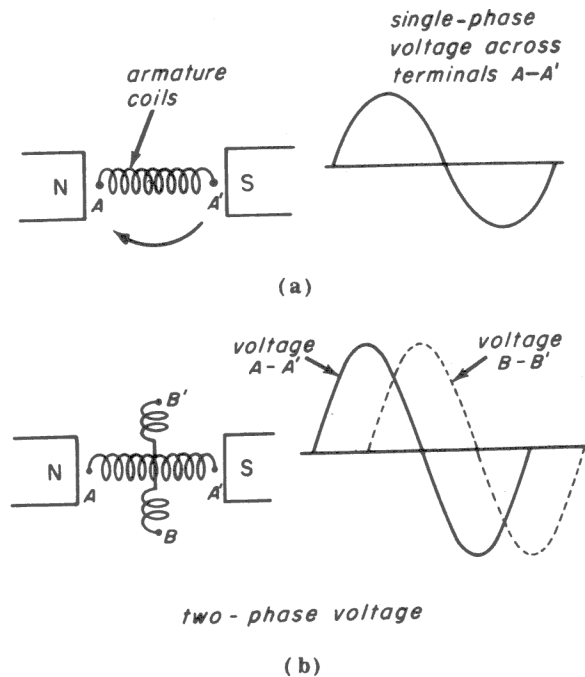


Fig. 22-11

tor so that it is separated by one quarter turn, or ninety degrees, from the first winding. This winding will also produce a sine wave output, but it will be separated, or out of phase, with the voltage from the first winding by one-quarter cycle or 90 degrees. If we combine the output of both windings we have a *polyphase* (more than one phase) alternating current. The output of both windings together is shown in the figure. This is called a *two-phase*, or *quarter-phase*, alternating current. Four wires are used to carry the two-phase current. (Three-wire operation is possible but not common). Usually, polyphase alternating current is available only to industrial users and is used only for fairly large motors. However, the principle of the generation of rotating magnetic fields can be seen most readily by considering the action of a two-phase supply connected to a four pole motor, as shown in Fig. 22-12.

The fields for the motor are produced by four field-windings. Two opposite windings are connected together and connected to one phase of the two-phase supply. The other two opposite windings are connected together and connected to the other phase of the two-phase supply. Thus the current in coils A and B will be 90 degrees out of phase with the current in windings C and D. Consequently, the field reproduced by coils

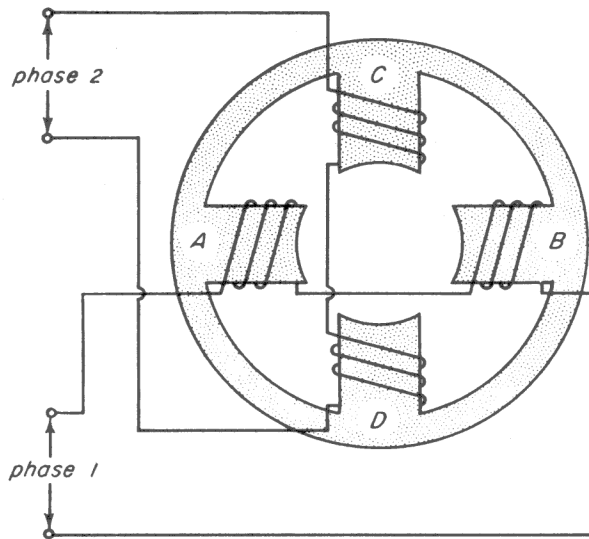


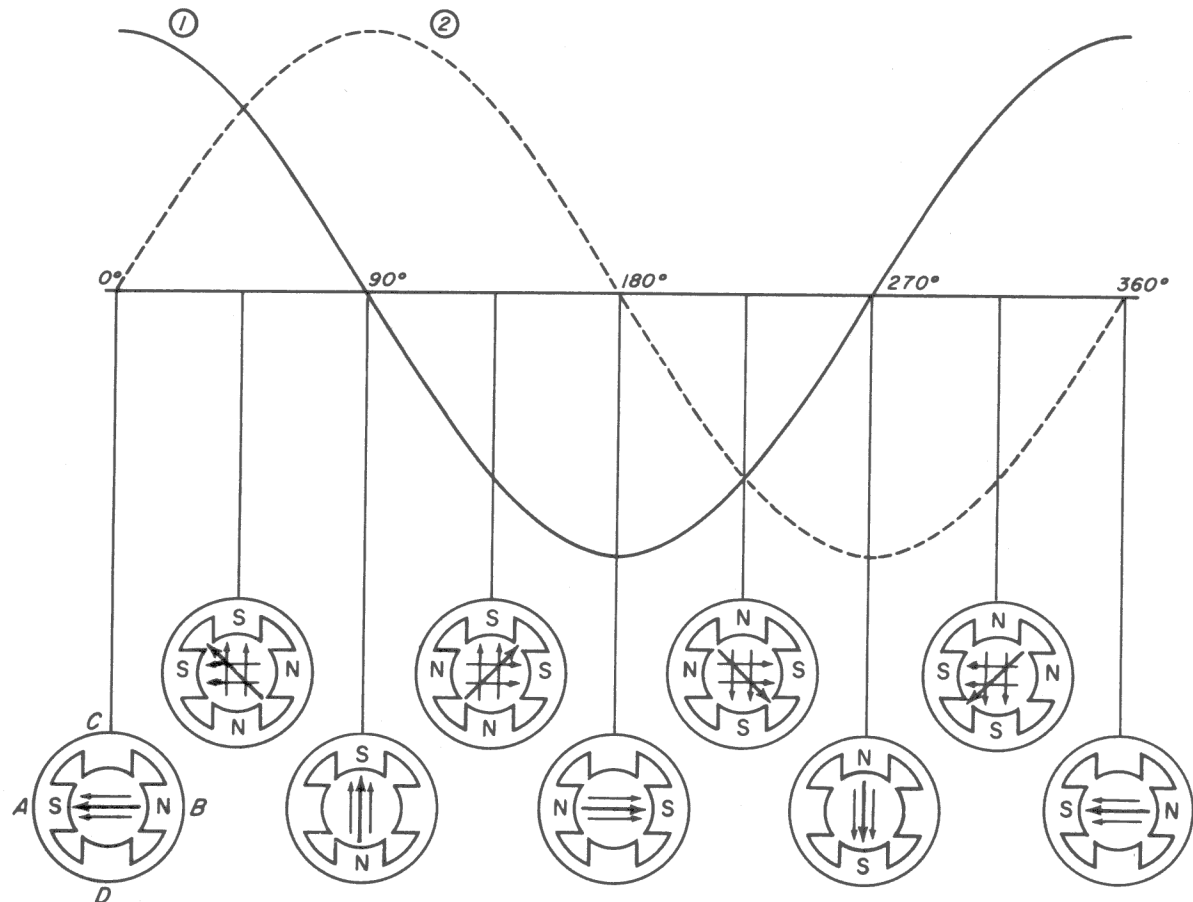
Fig. 22-12

A and B will be out of phase (separated in time) by 90 degrees. Also, because of the location of the two sets of coils, the field

produced by coils A and B will be separated in space by 90 degrees (one quarter turn). The effect of the 90-degree separation in both time and space is to produce a rotating magnetic field, as shown in the detailed drawings of Fig. 22-13.

A graph of the two-phase voltage supply used to energize the motor is shown at the top of the figure. The voltage represented by phase 1 is applied to coils A and B; the voltage represented by phase 2 is applied to coils C and D. The small motors drawn underneath the sine waves show the resultant fields produced by the two coils. The coils are not shown in these small drawings; the letters shown on the pole pieces refer to the coils located there.

Let us start at the left-hand side of the figure. The voltage of phase 1 is at a maxi-



short, light arrows ($\longrightarrow$) indicate direction of flux

long, heavy arrows ($\longrightarrow$) indicates direction of resultant field of force

Fig. 22-13

mum, while the voltage of phase 2 is zero. Current flows in coils *A* and *B*, setting up a south pole at *A* and a north pole at *B*, which produces a field from right to left, as shown. No current flows in coils *C* and *D*, and no magnetic field is set up by these coils. Because only the field of coil *A* and *B* is present, the resultant field is from right to left.

Then, 45 degrees, or 1/8 of a turn later, the voltage of phase 1 has gone to about 0.7 of its maximum value. The field of coils *A* and *B* remains in the same direction as before, and at almost the same strength. However, the voltage of phase 2, which previously was zero, has gone up to about 0.7 of the maximum value. Current now flows in coils *C* and *D*, making a south pole at *C* and a north pole at *D*, thus setting up a field from bottom to top. Both fields are now present — a field from left to right produced by coils *A* and *B*, and a field from bottom to top, produced by coils *C* and *D*, as shown. The two field combine to form a resultant field as shown by the long heavy arrow. Notice that the direction of the field has shifted one eighth of a turn or 45 degrees clockwise as a result of a change of 45 degrees in the applied a-c voltage. At 90 degrees, or a quarter cycle from the starting point, the voltage of phase 1 has gone to zero. There is no current flow in coils *A* and *B*, and no magnetic field set up from left to right. The voltage of phase 2, however, is now at a maximum, and there is a maximum field between coils *C* and *D* from bottom to top. Notice that the magnetic field has rotated a quarter turn in one quarter cycle of the applied voltage.

At the 135-degree point, the voltage of phase 1 has reversed itself. The magnetic field set up by coils *A* and *B* is opposite in direction to what it was at the 45-degree point. The reversed current flow sets up a north pole at *A* and a south pole at *B*, so that the direction of this field is now from left to right. The current in coils *C* and *D* is in the same direction as before, setting up a south pole at *C* and a north pole at *D*. The resultant field has the direction shown by the heavy arrow.

In the same way, you can follow the change in the direction of the fields as shown in the remaining diagrams of Fig. 22-13. The magnetic field will continuously rotate, making

one complete revolution for each cycle of the applied a-c voltage. If we suspend the closed loop of Fig. 22-10 between the poles so that it is free to rotate, it will be pulled around by the rotating field. The direction of rotation may be changed by reversing the connections of any one phase.

In practice, rotors consisting of many shorted loops are used to provide smooth power and considerable torque.

Synchronous Speed. The speed at which the magnetic field of the motor rotates is called its *synchronous* speed. It depends upon the number of poles, the number of phases, and the frequency of the a-c supply. The synchronous speed may be readily found from the formula:

$$S = \frac{120 f}{N}$$

where

S = the speed in revolutions per minute

f = the frequency of the a-c supply

N = the number of poles per phase

The two-phase four pole motor described previously has two poles per phase, so its synchronous speed is 3,600 rpm.

As pointed out previously, the motor cannot run at the synchronous speed, but must be slower. If the rotor conductors and the magnetic field were traveling at the same speed, the conductors would not be cut by the field, no current would be induced in them, and no torque would be developed. When a load is put on the motor, it slows down, and the relative speed of the conductors of the rotor with respect to the magnetic field is increased. This causes lines of force to be cut at a faster rate. More current is induced, and more torque is developed for the increased load. The difference between the synchronous speed and the actual speed is called the *slip*. The amount of slip depends on the load and is less for motors with more poles. The actual speed of a two-pole (per phase) motor will range from about 3,500 to 3,000 rpm, and the actual

speed of a 4-pole (per phase) motor will range from about 1,750 to 1,300 rpm.

22-3. SINGLE PHASE A-C MOTORS

Most homes are supplied with single-phase alternating current. Let us see, therefore, how single phase a-c motors operate. If we were to open up one of the two field windings of the two-phase motor shown in Fig. 22-13, no rotating field would be produced, and the motor would not rotate. However, if we allow the motor to start rotating first, and *then* open up one of the windings, the motor will continue to run at near synchronous speed, although with less torque than before. When the rotor is moving, conductors cut the stator field, and current is induced in the rotor. The induced rotor field and the single phase stator field combine to produce a rotating magnetic field that keeps the rotor moving. Thus, an induction motor may be operated from single-phase supply, provided some method is provided to start the motor.

A number of methods are used for developing the starting torque for single-phase motors. One method employs two separate windings, as in the two-phase motor, and makes use of the fact that a phase difference of approximately 90 degrees may be obtained by inserting a capacitor in series with one of the windings, called the auxiliary winding. The capacitor causes the current to lead slightly in this winding, while in the other winding the current lags, as in any inductance, so that a phase difference of about 90 degrees exists between the current in the two windings. Thus, as far as the windings are concerned, it is as if they are connected to a two-phase supply, and the motor operates in a manner similar to the two phase motor. In some motors, either the auxiliary winding is disconnected or a smaller capacitor is substituted, after the motor has started to rotate by a switch or relay that is operated by the rotation of the motor. This type of motor has a very high starting torque, and is used for pumps, refrigerators, air conditioners, large fans, etc. In some motors of this type, the capacitor winding is allowed to remain in the circuit at all times. Such motors have a relatively low starting torque.

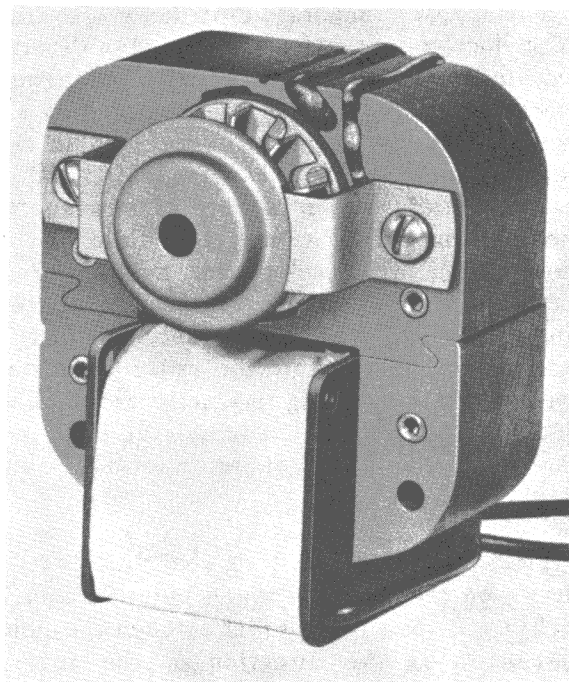


Fig. 22-14

Fractional horsepower motors used in phonographs or record changers are most often of the *shaded pole* type. A typical motor of this type is shown in Fig. 22-14.

In this type of motor, a slot is cut into the pole pieces so as to divide them into a larger part and a smaller part, as shown in Fig. 22-15. The smaller part of each pole piece is covered by a solid copper ring or coil, which is placed around it as shown. This part of the pole piece is called the *shaded pole*, while the larger part of the pole is called the *main pole*.

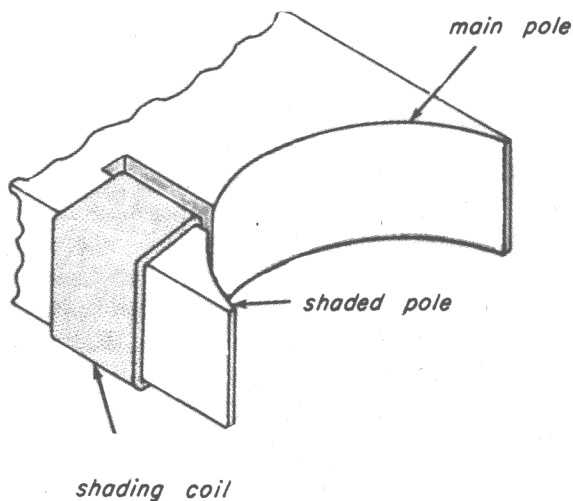


Fig. 22-15

The copper shading coil acts like the secondary of a transformer. The flux through the pole pieces is constantly changing, since the field winding is connected to alternating current. Current is induced in the shading coil by the changing flux, and a magnetic field is set up by this current in the shading coil. The magnetic field of the shading coil will add to and subtract from the main flux in such a way that a rotating magnetic field will be produced. Enough starting torque to start the motor is developed by this rotating magnetic field. The lines of force of the shading-coil field act to cancel the lines of force of the main field.

This current applied to the windings is shown on the curve between points 1 and 2 in Fig. 22-16a. The current through the pole pieces is in the direction of the arrows shown on the windings. As a result, a current in the opposite direction is induced in the shading coil. The magnetic field of the shading coil is opposite in direction to the main flux (whenever current is induced in a circuit, the direction of the magnetic field opposes the changing field producing it). The field of the shading coil is strongest closest to the shading coil. The lines of force of the total field will be as shown in Fig. 22-16a.

Between points 2 and 3 of the applied a-c current, the current through the field coil is changing very little. Therefore, little or no current is induced in the shading coil. The lines of force of the total field are as shown in Fig. 22-16b.

Between points 3 and 4 of the applied a-c current, the flux through the main pole is decreasing. The current induced in the shading coil opposes the decrease in flux. The lines of force of the field of the shading coil are in the same direction as the lines of force of the main flux and add to it. The flux is strongest in front of the shaded pole, and the lines of force are as shown in Fig. 22-16c. From an examination of the figures, you can see that the magnetic field has been made to shift. At first, the field is stronger at the top. Then it is uniform; then it is stronger at the bottom. As the strongest part of the field shifts from top to bottom, it pulls

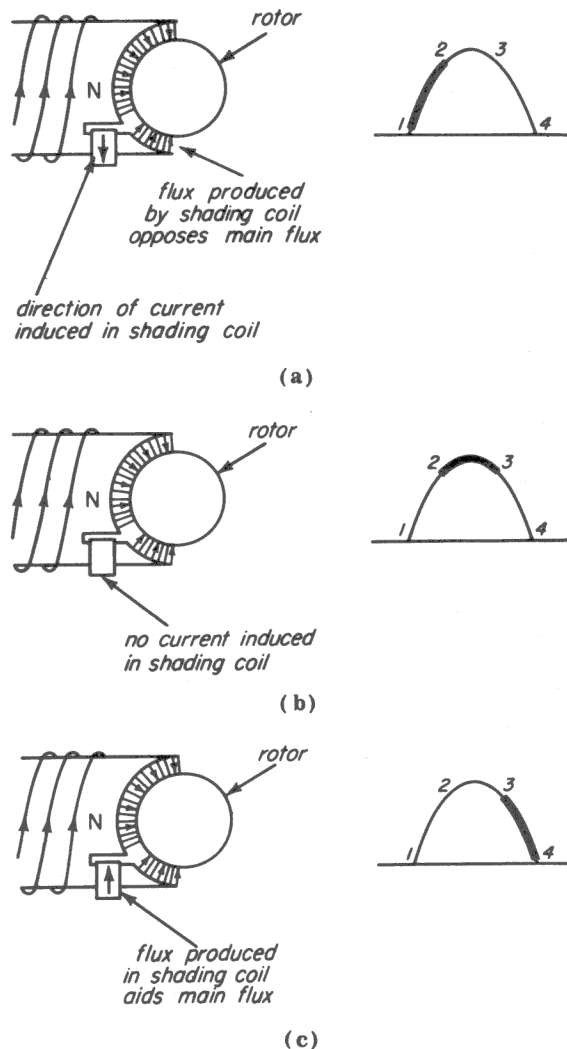


Fig. 22-16

the rotor around after it. In this example, the field is shifting in a counterclockwise direction. Therefore, the rotor moves counterclockwise. This starting torque is sufficient to start the rotor turning. After it has come up to the correct speed, the rotor gets most of the turning force from the main pole. Note that the direction of shift and the direction of rotor rotation is toward the shaded pole.

The construction of a typical shaded pole motor for use as a phonograph drive motor is shown in Fig. 22-17. Details of the rotor construction are shown in Fig. 22-18.

22-4. A-C/D-C MOTORS

The armature and field windings of a motor may be connected together in many different

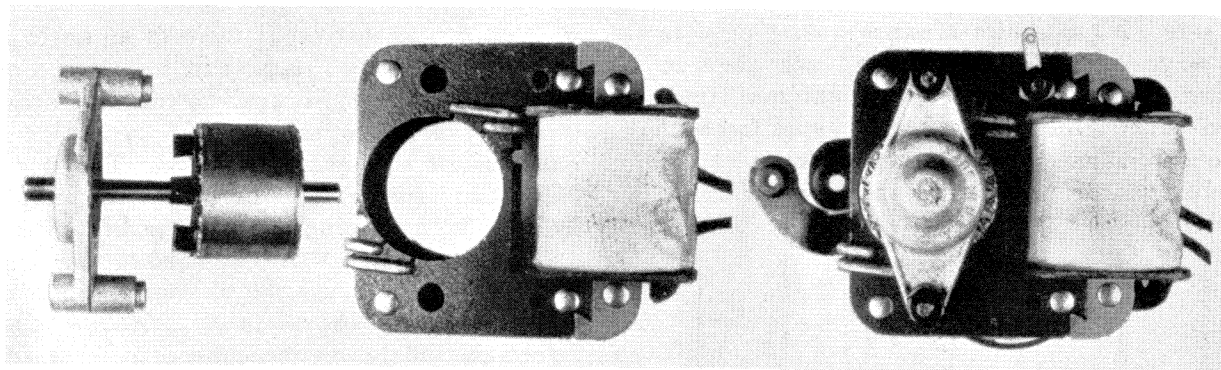


Fig. 22-17

ways. By varying the method of connection, different speeds, torques and other characteristics are obtained. For small motors, the series connection is widely used. The arma-

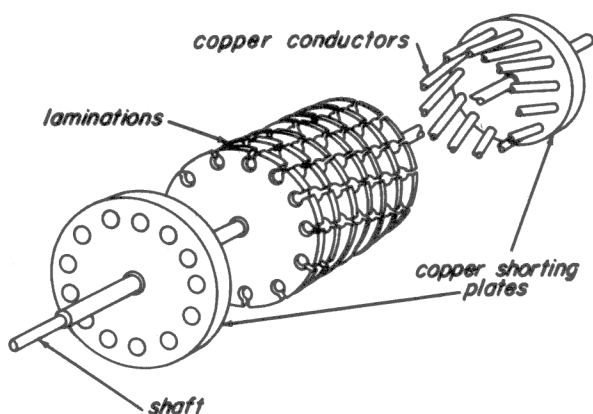


Fig. 22-18

ture and the field winding are connected in series across the line, as shown in Fig. 22-19. The construction of a series motor is shown in Fig. 22-5 and 22-6.

If this motor is connected across an a-c line, the direction of current in both the field and the armature change together. Therefore, the motor will operate on either a-c or d-c and, for this reason, it is sometimes called a *universal* motor. Another advantage of this

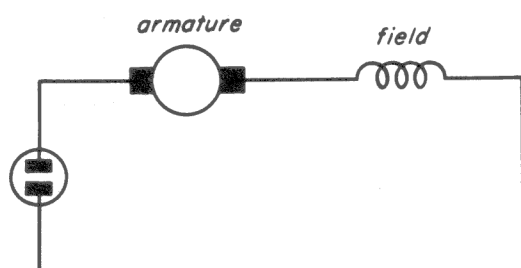


Fig. 22-19

type of motor is its high starting torque. These features make it a very popular motor for small home appliances. A disadvantage of the series motor is that its speed varies greatly under load. Therefore, it is not used where constant speed is required, unless a mechanical governor is provided to keep the speed constant. The speed of the series motor is greatly dependent upon the line voltage.

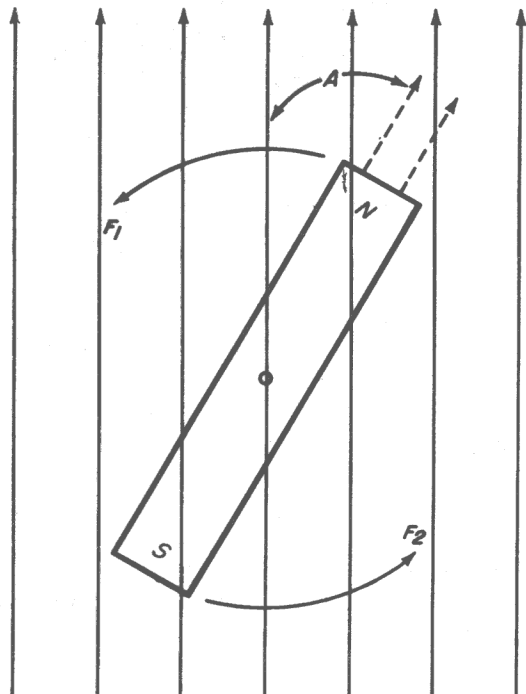
The series motor may be recognized by noting that it has a commutator to which the armature windings connect. The commutator may be a very simple one like that used on electric shavers, or a more standard type like that used on electric drills. Most electric drills, shavers, and similar small appliances use this type of motor. At the present time, it is not usually used in sound reproducing or recording equipment.

22-5. HYSTERESIS MOTORS

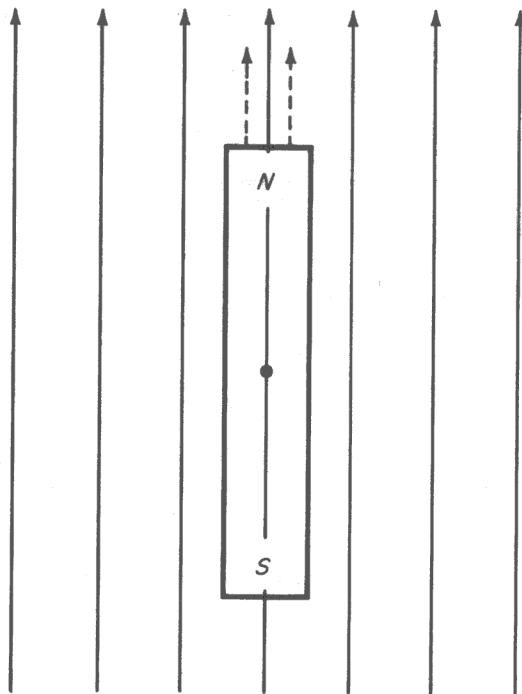
The hysteresis motor is widely used for recording equipment and other uses in which the motor must be very quiet, have very little vibration, and rotate with a very constant speed. Most a-c motors run below synchronous speed because a certain amount of slip is necessary for currents to be induced in the rotor, as explained in a previous section. The amount of slip varies with the amount of load applied, so that the speed varies with the load. The hysteresis motor, however, runs at exactly synchronous speed regardless of the load applied, if the load is within the rating of the motor.

The basic principle of the hysteresis motor is similar to that of the ordinary compass.

Figure 22-20a shows a bar magnet placed in a magnetic field. Solid lines are used to show the lines of force of the external field, and dashed lines show the lines of force of the bar magnet. If the lines of force of the field are not parallel to the lines of force of the bar magnet,



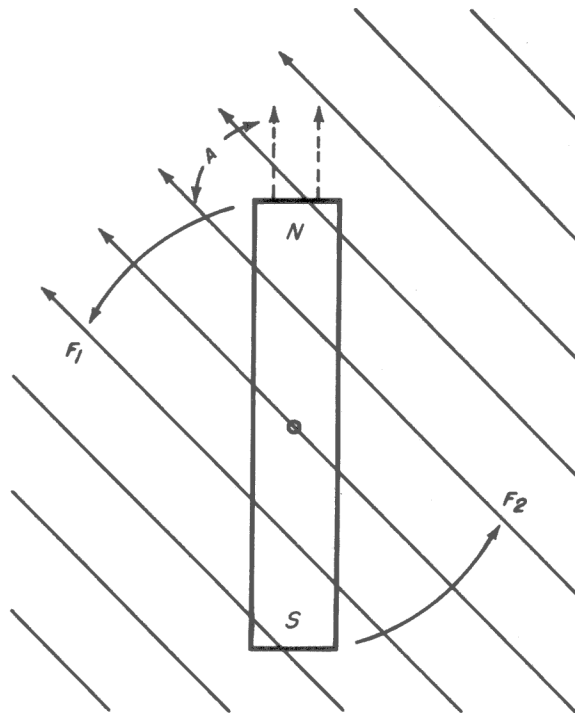
(a)



(b)

of the magnet, that is, if there is an angle A between them, then there will be a force on the magnet which will tend to turn it so that the lines of force will become parallel and pointing in the same direction. The north pole of the magnet will be pulled to the left by a torque or turning force F_1 , and the south pole of the magnet will be pulled to the right by a torque F_2 , until the magnet is parallel to the field as shown in Fig. 20-20b. The larger the angle A , the greater the turning force of the magnet; as the angle A becomes smaller the torque is reduced, until, when the angle becomes zero, there is no torque on the magnet. If we were to move the magnetic field to a new position, as shown in Fig. 22-20c, there would again be a torque on the bar magnet until it too had moved to the new position and lined itself up with the field. Thus, if we were to continually move the field around, the magnet would follow, and rotating motion would be produced. A shaft attached to the magnet could be used to turn a load. The various methods of producing a rotating magnetic field have already been described in a previous section.

In the hysteresis motor, the bar magnet is replaced by a rotor containing an outer shell



(c)

Fig. 22-20

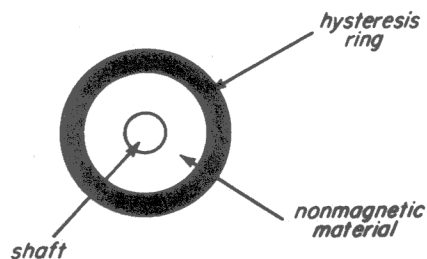
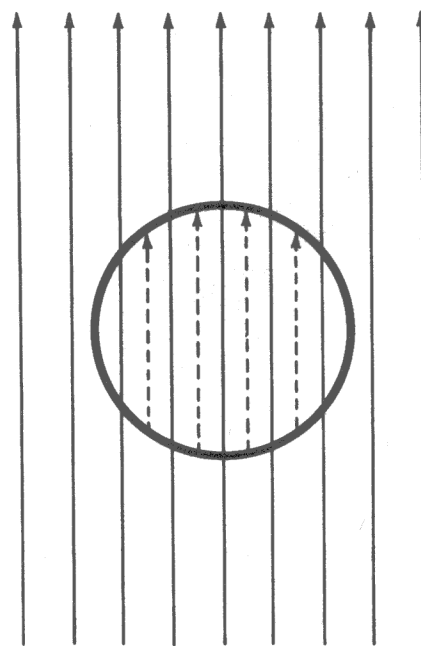


Fig. 22-21

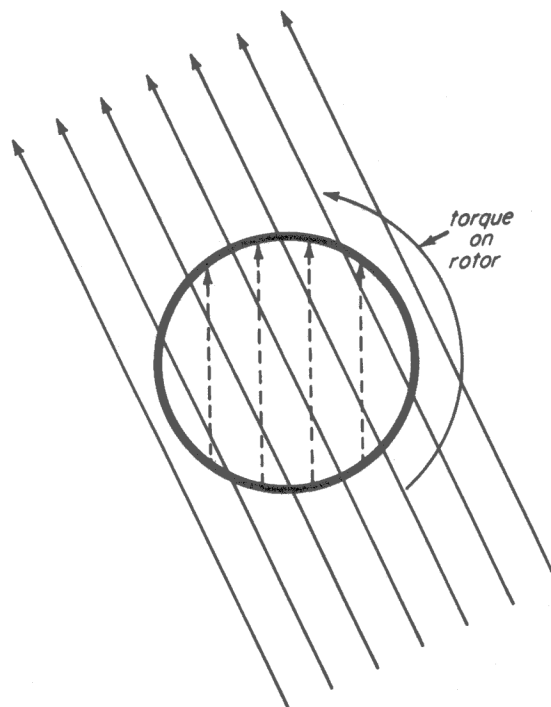
of high-reluctance magnetic material, as shown in Fig. 22-21. This outer shell is called the *hysteresis ring*. Materials of which hysteresis rings are made include hard steel, several of the Alnico alloys, and similar materials which make good permanent magnets. The word *hysteresis* comes from a Greek word meaning to lag behind, and it is used to describe the effect in high-reluctance magnetic materials, in which the magnetism remains or lags behind after the magnetizing force is removed. A magnetizing force applied to a magnetic material lines up all the molecules in the same direction. When the magnetizing force is removed, the molecules stay lined up in hard steel or similar materials because they are not free to turn back to their original positions.

If the rotor is placed in a magnetic field, as shown by the solid lines in Fig. 22-22a, magnetism is induced into the rotor, and it produces its own magnetic field, as shown by the dashed lines. If the magnetic field were to be moved to a new position, as shown in Fig. 22-22b, the magnetic field of the rotor would remain as before, because of the high reluctance of the material. Now there are two magnetic fields separated by an angle, and a torque is produced to turn the motor in the counterclockwise direction to line up the two fields. If the magnetic field is made to rotate continuously, the rotor will follow the magnetic field. The rotor will lag behind the rotating field by a certain fixed angle, but the rpm of the rotor will be exactly the same as the rpm of the rotating field.

The construction of a typical hysteresis motor is shown in Fig. 22-23. A rotating magnetic field is produced by the distributed two-phase stator winding. A capacitor is inserted in series with one of the windings is made to lead the current in the other



(a)



(b)

Fig. 22-22

winding by ninety degrees, and a rotating field is produced as previously explained.

The rotor usually consists of a cobalt ring on an aluminum cylinder. Other materials, such as hard steel or the various Alnico alloys, may be also used for the

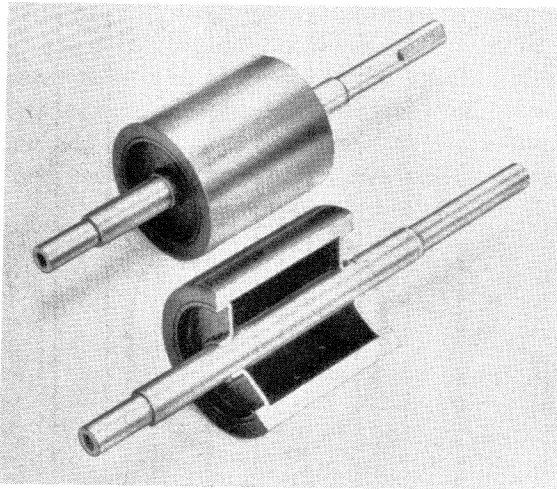


Fig. 22-23

outer hysteresis ring. The speed of the motor is determined by the frequency of the a-c supply and the number of poles in the stator field.

Motors used for tape-recording purposes require a provision for reversing the direction of rotation as well as changing the speed. In professional equipment, the motor speed is changed directly instead of using a speed-changing drive mechanism, as in phonograph motors. Figure 22-24 shows how the direction of rotation is reversed. The FORWARD REVERSE switch merely reverses the connections to one of the two phase windings. This causes the magnetic field to rotate in the opposite direction, and so reverses the direction of rotor rotation.

The principle of the speed-changing method can be seen in Fig. 22-25. Notice the symbol used for the motor windings. The

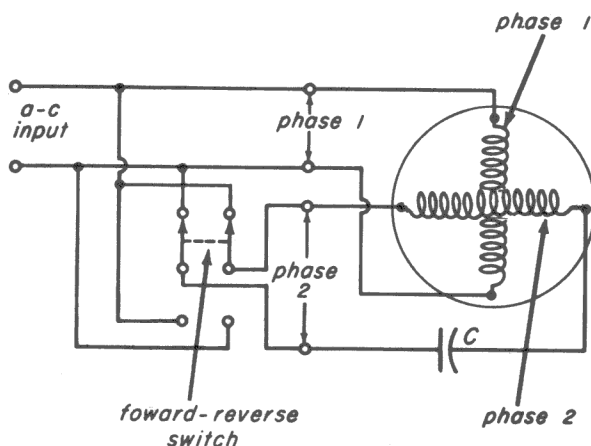


Fig. 22-24

A—high-speed winding
B—low-speed winding

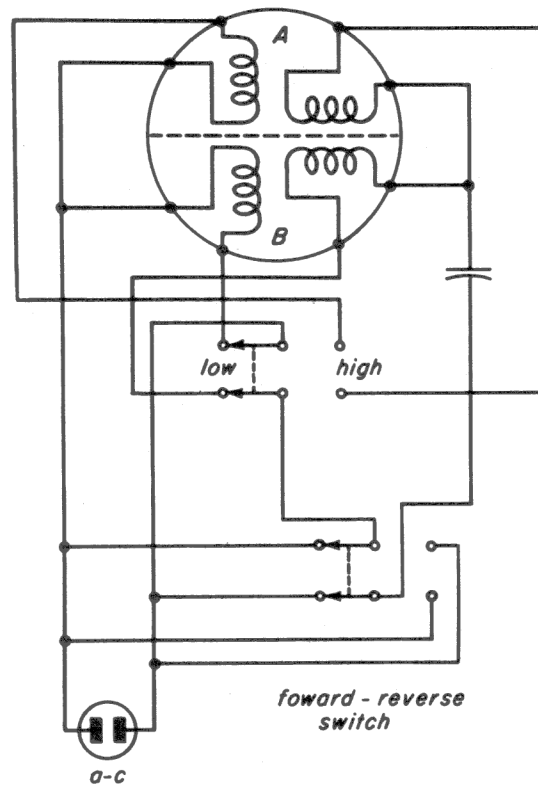


Fig. 22-25

two coils shown in Section A could have been shown as crossing coils as in Fig. 22-24.

The motor stator is wound so that it can be made into either a four-pole or an eight-pole motor by changing the switch. As previously described, doubling the number of pairs of poles cuts the speed in half. Several different arrangements of the stator field windings are possible. In the one shown in the figure, two separate windings are used. Winding A is distributed around the stator so as to produce four poles, which gives a synchronous speed of 1,800 rpm. Winding B is distributed around the stator to produce eight poles, which gives a synchronous speed of 900 rpm. The speed-change switch connects the a-c supply to one or the other set of windings. In each case, a capacitor is inserted in series with one section of the winding to obtain the 90-degree phase shift required to produce the rotating magnetic field.

22-6. PHONOGRAPH MOTORS

Electrical Connections. The electrical connections to the motor are usually quite simple, and consist of a series circuit that includes the motor, on-off switch, and a-c power cord. However, sometimes there are different arrangements of this simple circuit.

The basic motor circuit is shown in pictorial form in Fig. 22-26. The motor, on-off switch, and a-c line are all connected in series. The direction of rotation of the motor does not depend on the connections, so that it usually does not make any difference how the motor is connected to the a-c line. However, in some record players or automatic changers, less hum is produced if the motor is connected a certain way. In such cases, the motor leads are color-coded, and the manufacturer's data gives the correct connections. Most motors have a solder lug attached to the motor frame. This lug is used to ground the motor frame in order to keep hum at a minimum.

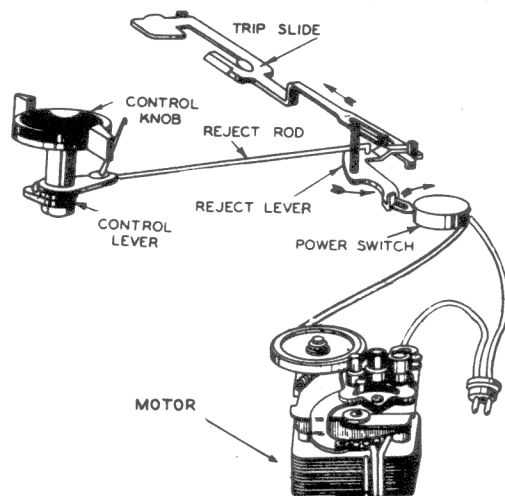


Fig. 22-26

In the circuit shown in the figure, the on-off switch is operated by the control knob through the control lever, the reject rod, and the reject lever. The power switch is turned off by the trip slide after the last record has been played.

Another arrangement that is sometimes used is shown in Fig. 22-27. Here switch S_3 is a momentary contact switch that is nor-

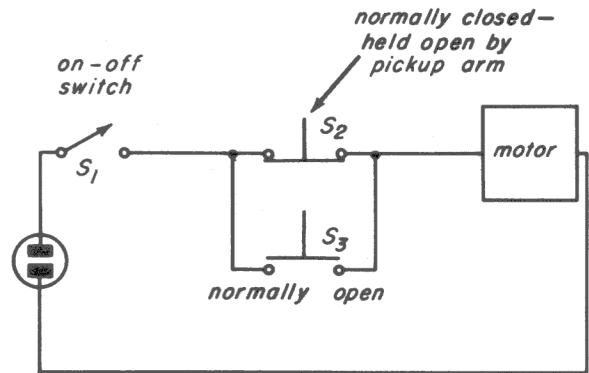


Fig. 22-27

mally open, and is closed only when it is pressed. Switch S_2 is normally closed, and is opened only when it is pressed. This switch is located on the motor board at the spot where the pickup arm lands after it has finished playing a record. When the pickup is at rest, this switch is open.

After the last record has played, the pickup arm is moved by the record-changer mechanism to its position at the edge of the record changer board. It is lowered onto switch S_2 , thereby opening it and automatically shutting off the motor. To start the changer, the operator presses down on switch S_3 , which is usually labelled *start*. This switch shorts out switch S_2 , which is open because the pickup is keeping it pushed down. Power is applied to the motor through the start button. This starts the pickup arm moving. As soon as the arm has moved away from switch S_2 , the operator may release pressure from switch S_3 , (the start button) and the record player will continue to operate.

The opening of switch S_2 by the pickup arm coming down on it after the last record has played may cause an annoying "plop" in the speaker. This is due to the spark produced by the opening of the switch. The spark is a high-frequency oscillation that is radiated and picked up by the amplifier and reproduced as a plopping noise. A resistor and capacitor may be connected in series across the switch contacts to prevent the plop. These components absorb the energy of the spark and do not allow it to be radiated. Typical values for such a filter are 0.1 mf and 100 ohms. Sometimes a capacitor alone is used. The voltage rating of the capacitor should be high because of the

high voltage produced across the switch contacts by the inductive kick of the motor windings.

Some changers do not have on-off switches. The motor is permanently connected to the a-c line and is turned on and off either by the power switch of the radio or amplifier or by the function switch of combination instruments.

The field winding of the motor may be wound so that it can be connected in series with the amplifier-tube filament across the a-c line. This arrangement is usually found in portable record players. A typical circuit uses a 25L6 amplifier tube and a selenium rectifier. The motor winding is used to drop the a-c voltage to the required value for the filament of the tube. If the filament of the tube burns out, the motor will not run.

Many times, the radio section of a radio-phono combination is an a-c/d-c transformerless receiver. This may give you the impression that the whole unit is a universal a-c/d-c radio-phono combination. Although the radio will operate on d.c., the phonograph motor will be burned out if connected to a d-c supply. The same applies to clock radios, where the radio section is usually an a-c/d-c receiver but the clock is a synchronous a-c motor. Never plug a clock radio or a radio-phono combination into a d-c supply. When in doubt about the type of power supply, check the power outlet with a neon tester to be sure.

Drive Mechanisms. The two-pole motor used in the typical record player rotates at about 3,000 rpm; four-pole motors rotate at about 1,700 rpm. But records are played on turntables that rotate at much lower speeds. The high speed of the motor must be reduced to the low speeds required for the turntable.

Since records may require a turntable speed of either 78 rpm, 45 rpm, or 33-1/3 rpm, a means must be provided for changing the turntable speed to any one of these three speeds. For record changers, power must be obtained from the motor to move all the gears, levers, pulleys, and cams that accomplish automatic record changing.

Two methods are used for transmitting power from the motor shaft to the turn-

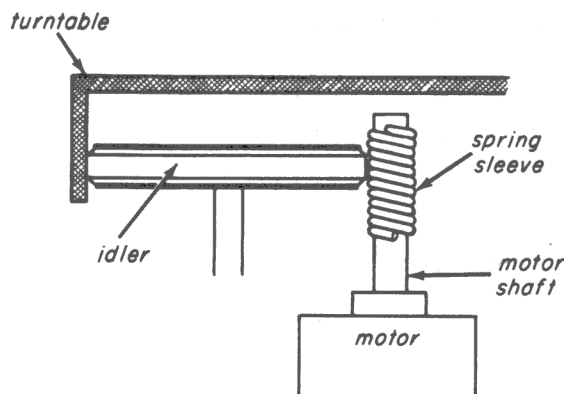


Fig. 22-28

table: *rim drive* and *gear drive*. At the present time, the rim drive method is used almost exclusively. The basic principle of the rim drive method is shown in Fig. 22-28. The motor is mounted near the edge of the motor-board so that the motor shaft is about an inch or so from the inside rim of the turntable. A small pulley, called an *idler wheel*, is mounted so as to press against both the motor shaft and the inside rim of the turntable. The idler wheel has a flat rubber tire around the outside to increase the friction between the motor shaft and the idler wheel, and between the idler wheel and the inside rim of the turntable. A *spring sleeve* is usually used on the motor shaft to adjust the outside diameter of the motor shaft to the exact size required. The idler wheel is kept against the motor shaft and inner turntable rim by spring pressure. When the motor shaft turns, it causes the idler wheel to rotate, which turns the turntable. The directions of rotation of the motor shaft, idler wheel, and turntable are shown in Fig. 22-29. Power from the motor is transmitted from the motor shaft through the idler wheel to the turntable. Since the idler wheel is so much larger than the motor shaft, it takes many revolutions of the motor shaft for one revolution of the idler wheel. And, for the same reason, many turns of the idler wheel are required for one complete turn of the turntable. Thus, there are two reductions in speed: one between the motor shaft and the idler wheel, and another between the idler wheel and the turntable, so the turntable runs at the required speed.

Speed-Change Mechanisms. Records are made to be played at one of three different speeds. The turntable speed of most record

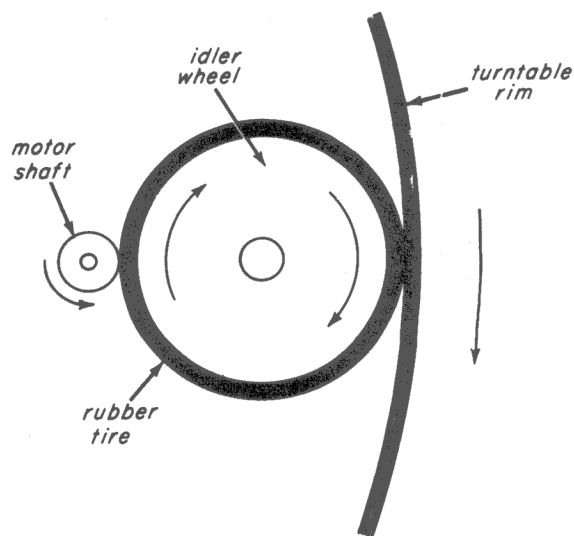


Fig. 22-29

players can be changed to any one of these three speeds so that all types of records can be used. Many different forms of speed-changing mechanism are used. A number of the most common methods are described in this section.

The basic principles of a speed-change mechanism can be seen in Fig. 22-30 and Fig. 22-31. A rubber belt connects the motor shaft to another shaft on the motor assembly. This second shaft or idler shaft is turning at all times with the motor shaft. The belt runs on a section of the idler shaft that is a little more than twice as large as the motor shaft, as can be seen from the illustrations. This causes the idler shaft to run at a little less than half the speed of the motor shaft. The speed-change lever moves either the motor shaft or the idler shaft into contact with the idler wheel. Spring pressure keeps the idler wheel against the inner rim of the turntable

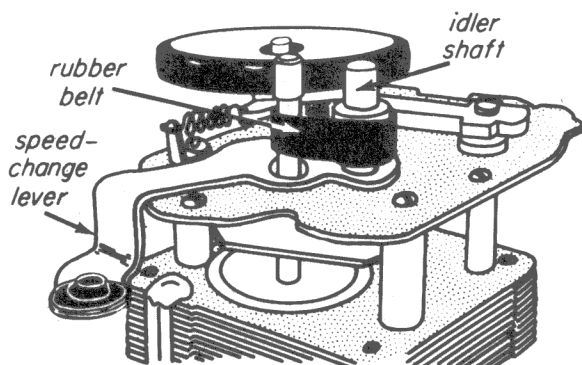


Fig. 22-30

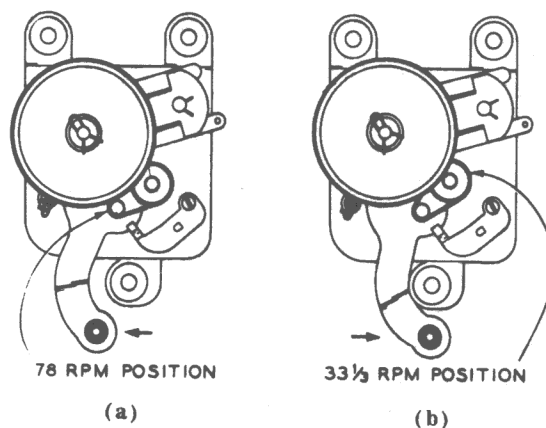


Fig. 22-31

at all times. Power is transmitted in one of two ways: from the motor shaft to the idler wheel to the turntable; or from the motor shaft, through the idler shaft, through the idler wheel, to the turntable. When the idler wheel is pressed against the motor shaft as shown in Fig. 22-31a, it turns the turntable at 78 rpm. When the idler wheel is pressed against the idler shaft, as shown in Fig. 22-31b, it turns the turntable at 33-1/3 rpm. By using two belts and two idler shafts, this method can be used to obtain 3-speed operation.

Another type of speed-change mechanism is shown in Fig. 22-32. The shaft of the motor has sections of three different diameters. Power is transmitted from the motor shaft through the idler wheel to the inner rim of the turntable. For a particular speed, the idler wheel is raised or lowered to bring it into contact with a particular section of the motor shaft. The idler wheel is always kept in contact, by spring pressure, with

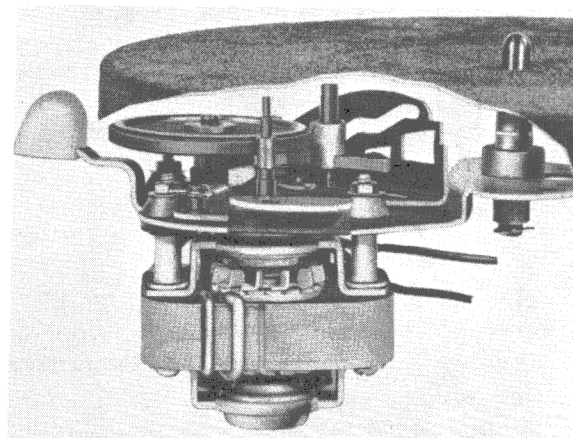


Fig. 22-32

both the inner rim of the turntable and the motor shaft. The smaller the section of the shaft that is in contact with the idler wheel, the slower the idler wheel will be turned, and the slower the turntable will rotate. When the idler wheel is in contact with the lowest section of the motor shaft, which has the largest diameter, the idler wheel turns at its fastest speed, and the turntable speed is 78 rpm. Bringing the idler wheel in contact with the center section of the motor shaft, which has an intermediate diameter, makes the turntable rotate at 45 rpm. With the idler wheel in contact with the top (smallest) section of the shaft, the turntable rotates at $33\frac{1}{3}$ rpm. The speed changer lever moves the idler wheel up and down to contact the different sections of the motor shaft.

The manner in which the speed change lever raises and lowers the idler wheel may be seen in Fig. 22-33. The person operating the phonograph turns the speed change knob to the proper position for the speed of the record he is going to play. In the figure, the pointer on the speed change knob points to the 78 rpm position. With the knob in this position, the lowest level (level 1) of the

three-level cam is pressed against the idler-wheel holder. The pressure of the cam presses the idler wheel holder up against the spring. The idler wheel holder pushes up a shaft that holds the idler wheel against the 78-rpm section of the stepped shaft.

If the speed change knob were in the 45-rpm position, level 2 of the cam would press against the idler-wheel holder. As a result, the idler-wheel holder would be pushed higher than when level 1 of the cam is under it, and the idler-wheel holder would press the idler wheel up to the 45 rpm section of the stepped shaft.

When the speed change knob is in the $33\frac{1}{3}$ -rpm position, level 3 of the cam is under the idler wheel holder, and, as a result, the idler wheel is held against the $33\frac{1}{3}$ -rpm position of the stepped shaft.

A third method of changing turntable speed is shown in Fig. 22-34. This method uses three idler shafts mounted on a plate that is rotated by the speed-change lever. One of the three idler shafts is placed in contact with the motor shaft for a particular speed. Each idler shaft turns the idler wheel,

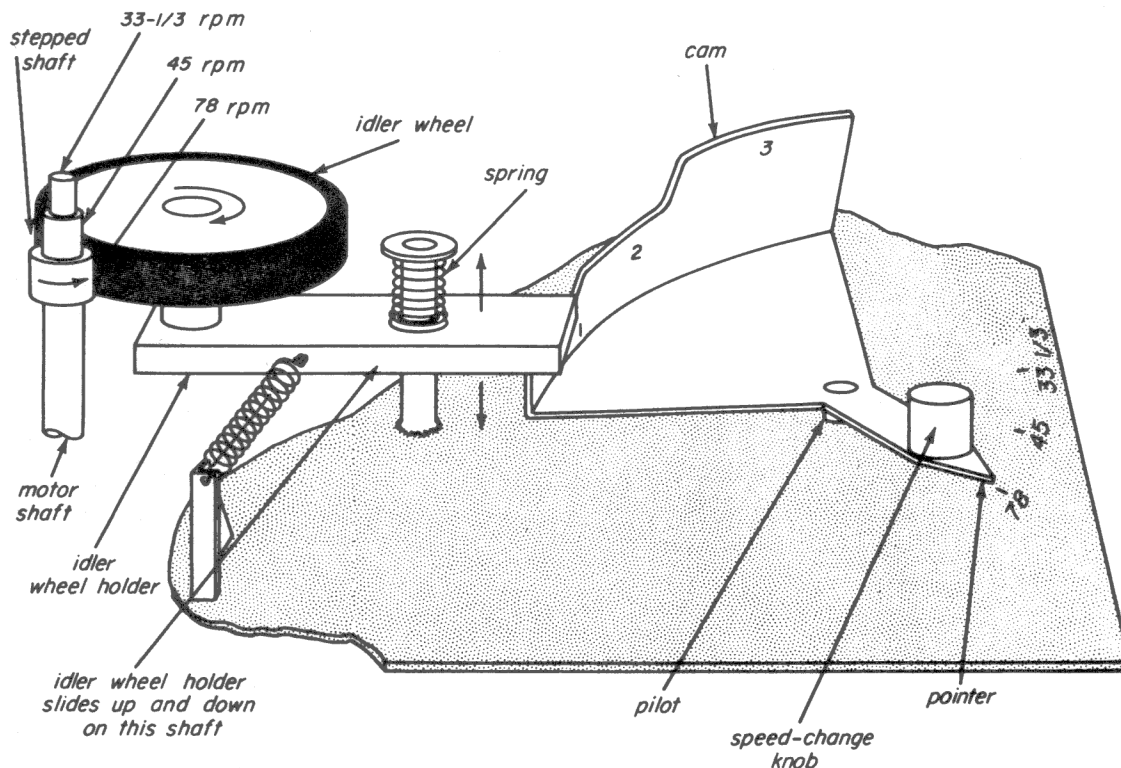


Fig. 22-33

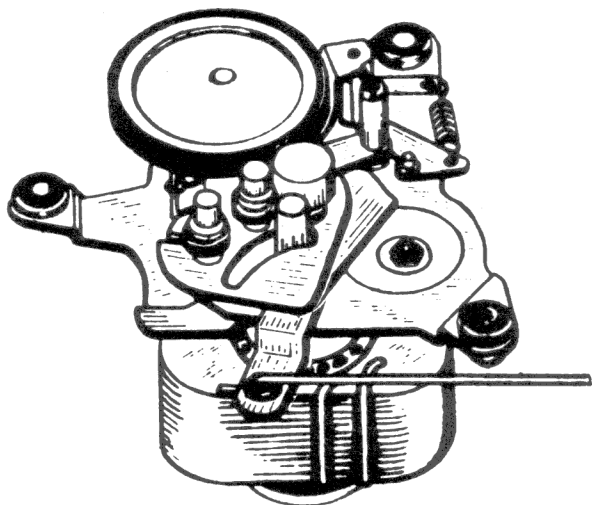


Fig. 22-34

and, through it, the turntable, at a different speed, because of the change in the diameter of the shaft. The smaller the portion of the idler shaft in contact with the idler wheel, the slower the turntable speed is.

Many record changers have a neutral, or off, position as a part of the 3-speed drive mechanism. The purpose of this is to release the idler wheel from the drive shaft when the record player is not in use. Prolonged pressure of the drive shaft on one point of the idler wheel when the record player is not in use for long periods will produce a flat spot on the idler wheel. This will cause a thumping sound when records are being played. If the record changer has an off position on the speed change knob, it should always be turned to off when the record changer is not in use to prevent these flat spots from occurring.

Lubrication. Most phonograph motors are factory lubricated. With normal use, they do not require additional lubrication for a long time. Some manufacturers state that lubrication is not needed until after 1000 hours of operation. However, motors that are used a great deal or operate under unusually high temperatures may need lubrication at shorter intervals. Many phonograph motors are provided with felt washers surrounding the motor bearings. These felt washers are saturated with oil so that the bearings are always lubricated. A few drops of oil may be added to these felt washers if they appear dry.

A light machine oil, such as SAE #10, generally may be used to lubricate the motor bearings, idler wheel pulleys, and other parts of the drive mechanism. However, if the specific instructions for the motor are available, they should be consulted to determine the proper type of lubricant. For example, some manufacturers specify a sewing machine oil for motor lubrication.

Always use oil very sparingly, and wipe off any excess. Over-lubrication of any electrical machine is dangerous. *Never get oil or grease on any rubber parts or on the inside rim of the turntable.* Carbon tetrachloride, alcohol, or naphtha should be used for wiping off any oil or grease that gets on rubber parts. If rubber belts are used in the drive mechanism, it is a good idea to remove them before lubricating and wipe off any excess oil before replacing them.

Caution. The vapors of carbon tetrachloride are poisonous. Use it only in a well-ventilated room, and do not inhale the vapors. Keep the carbon tetrachloride in a tightly closed, clearly marked container.

If the motor has an accumulation of dirt and gummed up oil, the dirt and old lubrication should be removed with kerosene or carbon tetrachloride before the motor is lubricated.

Checking Turntable Speed. In order for recorded speech or music to be reproduced so that it sounds right, the turntable must be rotating at the correct speed. If the turntable rotates too slowly, the pitch of the reproduced sounds will be too low, and the tempo or rhythm will be too slow. On the other hand, if the turntable runs too fast, spoken words will be run together so that they are hard to understand, the pitch of the reproduced sounds will be too high, and the rhythm will be too fast.

There are two ways in which the speed of the turntable may be checked: by counting the number of revolutions made by the turntable in a certain time, and by using a *stroboscope* disk. The stroboscopic method is the most accurate, but the first method can always be used when the speed of a

turntable needs to be checked and a stroboscope disk is not on hand.

To measure the speed of the turntable by the counting method, a watch or clock having a sweep-second hand is required. The speed should always be checked under load, that is, with a record on the turntable, and the pickup arm on the record in playing position. A mark is made on the edge of the record, or a small piece of paper is taped in place on the edge of the record to serve as a marker. After the turntable has come up to its full speed, the number of revolutions made by the marker in a minute is counted. This gives the rpm of the turntable. If desired, the counting can be done for only $\frac{1}{4}$ minute, and the result can be multiplied by four; however, counting for a full minute is more accurate. Do not attempt this method unless either a sweep-second hand or a stop watch is available.

The stroboscopic method calls for a stroboscope disc, which is placed under an alternating current light source. A typical stroboscopic disk is shown in Fig. 22-35. The stro-

boscopic method of speed checking is based on the fact that any lamp that is operated from an a-c source actually turns light and dark 120 times a second (if the frequency of the a-c source is 60 cps). This is shown in Fig. 22-36, where the light output for different parts of the a-c cycle is indicated. Whenever the a-c wave goes through zero, which it does twice during every cycle, the light from the lamp becomes very dim. As can be seen from the figure, the light from the lamp is dim except near the positive and negative maxima. The times during which the light from the lamp is bright are separated by $\frac{1}{120}$ th of a second. Although this dimming of the light from an a-c operated lamp usually cannot be seen, because it happens so fast, it does become noticeable when such light is used to look at rapidly moving objects.

A very simple stroboscopic disk is shown in Fig. 22-37. It has one black segment on a white background. Let us set this disk turning and look at it by light from an alternating source that is going on at intervals of $\frac{1}{120}$ th of a second.

If the speed of the disk is such that the black segment comes into position at point



Fig. 22-35

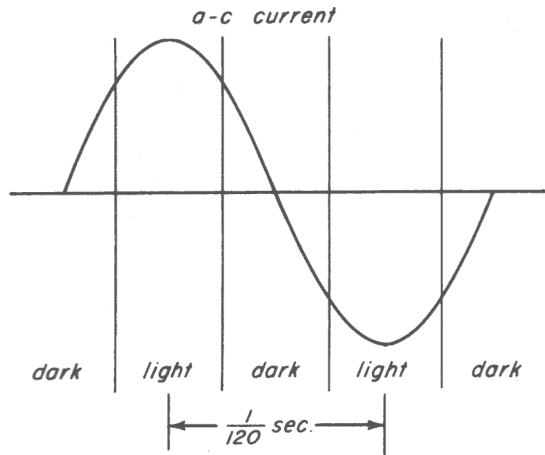


Fig. 22-36

A just when the light comes on, and then travels fast enough to go completely around and get *back into position at A* just as the lamp goes on again, the segment will appear to be standing still. Whenever the lamp goes on, the black segment is always seen in the same place. Therefore, it appears that the black segment has not moved. In order for this to happen, the black segment must go completely around, in $1/120$ th of a second. One revolution in $1/120$ th second is the same as 120 revolutions per second, or $120 \times 60 = 7,200$ rpm. If a disk containing one segment is placed on a turntable and appears to be standing still when looked at under 60-cycle light source, it must be rotating at 7,200 rpm. This is, of course, much too high a speed. The stroboscope disc with a larger number of segments can be used to test rotation at much lower speeds. The speed at which the turntable is rotating can be found by the formula:

$$rpm = \frac{120 f}{n}$$

where:

n = number of black segments on the disc,

f = frequency of the light source

rpm = turntable speed in revolutions per minute.

This formula gives the *lowest* speed at which the disk will appear to stand still; the disk will also appear to stand still when rotated at multiples of the speed given by the formula.

1a. Since the approximate speed of the turntable is known, this causes no confusion.

A stroboscope disk for checking a turntable for rotation at 78 rpm under 60-cycle light usually contains 92 segments. If the disk appears to stand exactly still, its speed of rotation is 78.26 rpm, which is the speed at which 78-rpm records are recorded. Most stroboscope disks contain sections for checking all three standard speeds ($33\frac{1}{3}$, 45, and 78 rpm) at 25, 50, and 60 cycles, and they are clearly labelled so that the serviceman usually does not have to make calculations involving the above formula.

To use the stroboscope, place the phonograph where it will be underneath a lamp operated from an a-c supply and away from daylight. Any lamp will do, but a clearer indication will be obtained with fluorescent or neon lamps, since they actually go out when the a-c voltage goes to zero, while an incandescent lamp continues to glow dimly.

Put a record on the turntable, place the stroboscope disc on top of the record, and put the pickup on the record near its outer edge.

See that the disk lies flat on the record so that it will be carried around by the record without slipping. Observe the black segments on the correct section of the disc while it is rotating. If they appear to stand still, the turntable is rotating at the correct speed; if the segments appear to move slowly forward, the turntable is rotating faster

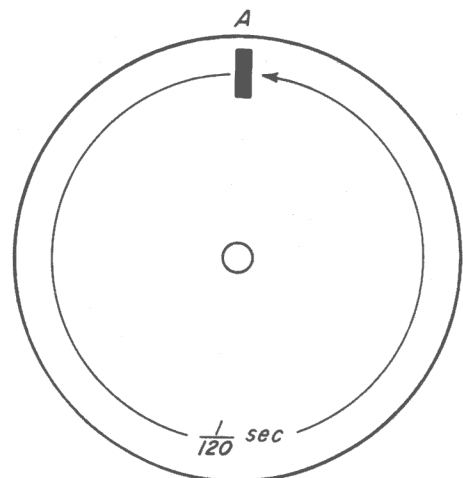


Fig. 22-37

than the correct speed; if the segments appear to be moving backward, the turntable speed is too slow. Check all speeds of a 3-speed machine. Careful observation of the disc will show up any wow or speed variation during one revolution of the turntable. For possible causes of incorrect speed or wow, refer to the section on troubleshooting.

22-7. REPAIR OF PHONOGRAPH MOTORS

The shaded pole motors used in phonographs are very simple and rugged. They require very little maintenance, and, in most cases, the trouble is not in the motor itself. When such motors develop trouble it is usually cheaper to replace them than to try repairing them.

Motor Does Not Turn. If the turntable does not turn, first check whether the motor is turning, since there are usually several pulleys, belts, or idler wheels between the high-speed motor spindle and the low-speed turntable. If the motor does not turn, it may be for one of the following reasons:

- a. Current is not reaching the motor.
- b. The motor is jammed by the external mechanism.
- c. The motor is defective. The defect may be an open field coil, jammed motor bearings, or defective rotor.
- d. Insufficient starting torque is developed, due to low line voltage or a partially shorted field coil.
- e. There are solid particles or dirt accumulation between stator and rotor jamming the motor.

A quick check to tell whether current is reaching the motor is to touch a screwdriver to the motor frame near the field coil. The screwdriver will be attracted to the frame if flowing in the field coil. If current is not flowing in the coil, check the a-c wiring to the motor and the switches in series with the motor. If no defect is found here, the field winding of the motor is open.

To check whether the motor is jammed, push the idler wheel away or remove any

belts so that nothing is bearing against the motor spindle. If the motor then rotates, the record-changer mechanism is jammed.

If the motor still does not rotate, try turning the motor rotor by hand while the idler wheel or belts are kept away. It should rotate freely; otherwise either the motor bearings are jammed or the rotor is jammed against the field poles for some reason. Unless the cause is immediately seen and easily repairable, the motor should be replaced.

If the motor turns, but the turntable does not, push the idler wheel away from the inner rim of the turntable and spin the turntable by hand. If it does not spin freely, the most probable causes are binding of the turntable shaft and lack of lubrication. If the turntable spins freely, the cause may be bound by checking the drive mechanism between motor shaft and inner turntable rim for missing parts, loose or missing springs, grease or oil on rubber parts, and loose or missing drive belts.

Low Turntable Speed. If one speed of a two- or three-speed record player or changer is correct, the motor speed is correct, and the defect is definitely in the drive mechanism.

Incorrect turntable speed is usually caused by some defect in the drive mechanism rather than the drive motor itself. Occasionally, however, the drive motor is at fault, in which case it usually must be replaced.

If the turntable speed is too slow, make sure that there is no oil or grease on the inside rim of the turntable, or on any of the rubber tires of the idler wheels, or on the motor spindle. See that the idler wheel is able to press against the motor shaft and the inner rim of the turntable and that the tension spring has sufficient tension to keep the idler wheel against the motor shaft. However, if the idler wheel is too tight, rumble may result. Clean all of these surfaces with carbon tetrachloride, alcohol, or naphtha. Move the idler pulley away from the inner rim of the turntable and spin the turntable by hand to see that it moves freely and easily. Some possible causes of low turn-

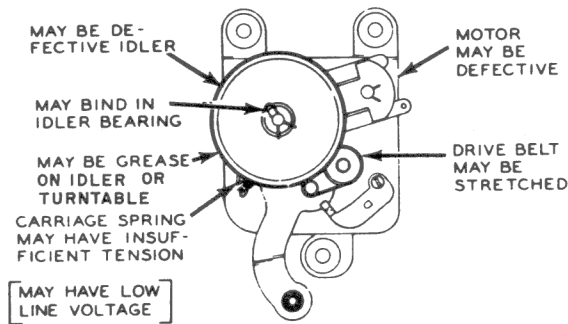


Fig. 22-38

table speed are shown in Fig. 22-38. If the idler wheel is worn or the drive belts are loose or worn, replace them.

Line voltages below about 105 volts or low temperatures (below 60° F) may also cause the turntable speed to be too low. After checking all of these things, if the turntable does not come up to speed, the fault is most probably in the drive motor itself. The defect may be a bind in the motor bearings, shorted turns on the field winding, or a damaged rotor. Replace the motor.

Turntable runs too fast. This trouble is usually due to incorrect parts installed in the drive mechanism, such as pulleys of the wrong size or the wrong spring sleeve on the motor shaft. In the case of a new phonograph that runs fast, it may have been set up to operate on 50 cycles instead of 60 cycles. To remedy this condition, see the section on 50 to 60 cycle conversion.

Wow. Wow is a term that describes a variation in the speed of the turntable during each revolution that causes regular changes in pitch of the sound being reproduced. The turntable speed must be very constant; otherwise the variation in speed will be heard as a low-frequency variation or wow in the loudspeaker. A flat record should be used when testing for wow, as a warped record may cause wow in the output even though the turntable speed is constant. Wow may be caused by a worn spot on the idler wheel, grease or oil on some part of the driving mechanism, a defective motor, or other causes as shown in Fig. 22-39. The motor defect is usually either bad bearings or a rotor that has been knocked out of alignment. If the room is very quiet, you can sometimes hear the speed variation in the motor itself

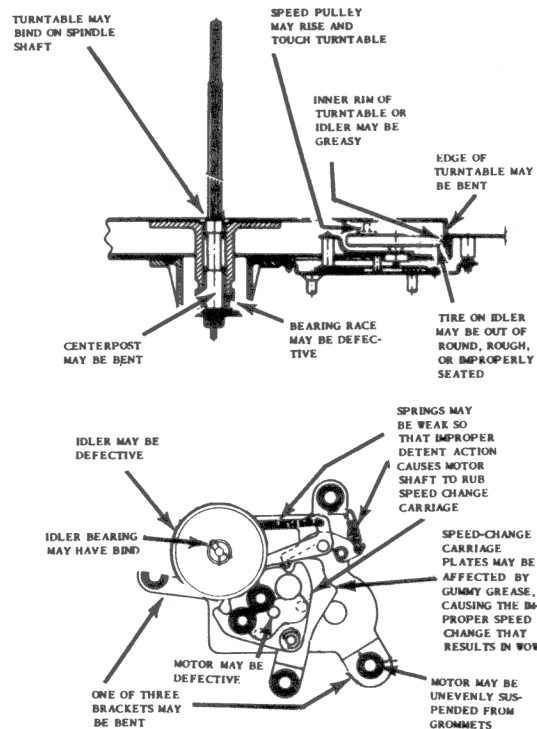


Fig. 22-39

by putting your ear very close to the motor and listening to it run. The motor should run very smoothly without any thumping or audible change in speed.

Rumble. Rumble is a term used to describe the effect produced in the loudspeaker when vibrations from some cause are transmitted to the pickup arm of the record player. Rumble is heard as a roaring low-pitched sound something like thunder. In order to prevent vibrations from reaching the pickup arm, the record-player turntable assembly is shock mounted, either on springs or rubber grommets. Also, the drive motor is suspended on rubber grommets to prevent any motor vibration from reaching the turntable. Some possible causes of rumble are shown in Fig. 22-40. The motor should not be mounted so as to touch any other component. If the motor leads are pulled tight, they may transfer vibration from the motor to the turntable; therefore, they should be left slack. Dried-up or hardened rubber grommets should be replaced. If the motor is loose in its mounting, or the motor rotor is out of alignment, or the bearings need lubrication, rumble may be produced.

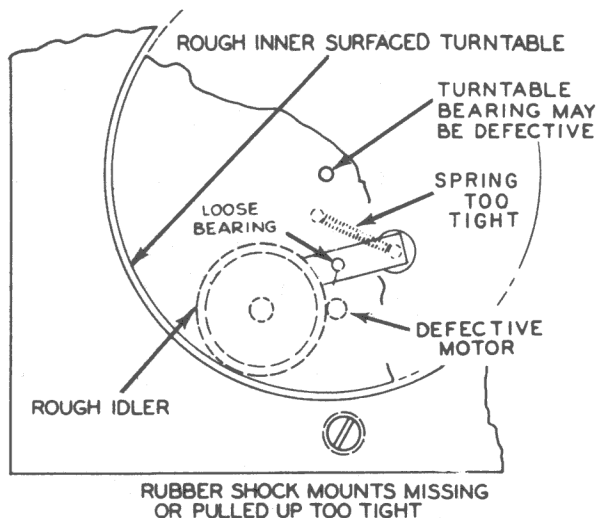


Fig. 22-40

Other causes of rumble that are shown in the figure are a rough rubber tire on the idler wheel, a loose bearing in the idler wheel pulley, or too much pressure of the idler pulley on the motor shaft. Defects in the turntable, such as a defective turntable bearing or a rough surface on the inner rim of the turntable, may also be causes of rumble.

Thumping. The motor spindle, which rotates against the idler wheel, may sometimes cause one spot on the idler wheel to wear more than the rest. As the idler rotates, this worn spot hits against the motor spindle and causes a thumping sound. The wear may be produced by the pressure of the motor spindle against one spot on the idler wheel for a long period, due to infrequent use of the changer. Another cause is the jamming of the changer mechanism, which allows the motor spindle to rotate while held at one point of the rubber tire, thus wearing a groove in it. The remedy for this defect is to replace the rubber tire or idler wheel pulley.

Failure to Change Speed. When the speed change knob of a three-speed record player fails to change the turntable speed, it is usually due to a bent, broken, loose, or missing part in the linkage between the speed-change knob and the speed-change mechanism at the motor. Some causes of failure to change speed are shown in Fig. 22-41.

Repair of Series Motors. Most of the troubles with this type of motor are due to defects of

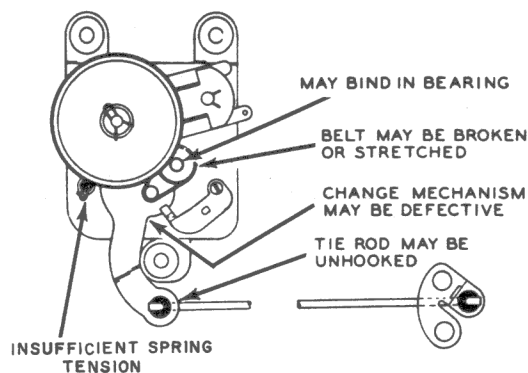


Fig. 22-41

the brushes or commutator. Other troubles are best handled by an experienced motor repairman.

Motor does not run. This is probably due to the armature not receiving any current due to worn or defective brushes. Figure 22-42 is brush-holder assembly. The brushes are not firmly pressed against the commutator. New brushes are usually about 1/2-inch or 3/4-inch long when new. Replace them if they are worn down to less than half of their original size, and replace the spring if it does not exert enough tension on a new brush. Also check to see that the brushes are free to move up and down in the brush holder. Scrape the sides if necessary with a knife or sandpaper until they move easily. However, the brushes should not be loose enough to move from side to side in the brush holder. New brushes must be curved to match the surface of the commutator, as shown in the figure, so that the whole area of the brush rests on the commutator. If this is not done, excessive sparking will result and burn a hole or a groove in the commutator. New brushes for replacement may be curved to fit; otherwise, they should be shaped by placing a piece of sandpaper between the brush and commutator and working it back and forth until the brush surface has the right curvature. *Never* use emery cloth or

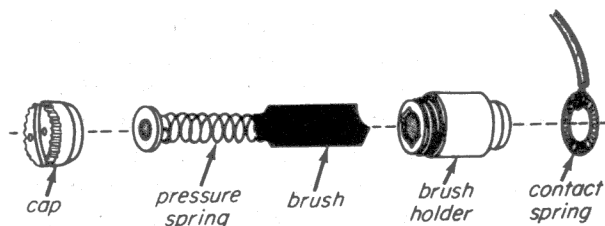


Fig. 22-42

any other abrasive sheet that contains metallic particles.

The commutator should be kept very clean and free from any lubrication. While the motor is running, polish the commutator by holding a clean, soft rag against it until it is bright and shiny.

Caution: Do not use your fingers to hold the rag; wrap it around a small stick and carefully press the rag on the stick against the commutator.

If the commutator is badly pitted, or has grooves cut into it, or has loose or uneven segments, it is best to take it to a motor repair shop to be turned down.

Conversion From 60 to 50 Cycles. As you have seen in a previous section, the speed of a synchronous motor is directly proportional to the frequency of the a-c supply. If a phono motor and turntable combination that has been designed to produce the correct turntable speed at 60 cycles is operated from a 50-cycle a-c supply, the turntable will revolve too slowly. If a 60-cycle phonograph whose correct turntable speed is 78 rpm is operated from a 50-cycle supply, the turntable speed will be 65 rpm. This error is enough to cause a very noticeable change in the speech or music being reproduced. The reverse will occur if a machine designed to operate on 50 cycles is operated from a 60-cycle a-c supply.

Phonographs made to operate at 60 cycles may be converted to operate at 50 cycles by

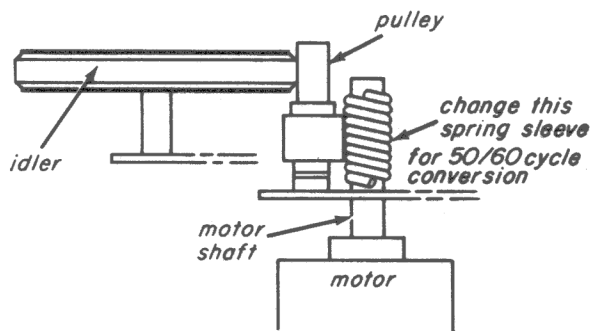


Fig. 22-43

changing the spring on the motor shaft for one of a larger outside diameter. The increased outside diameter will speed up the idler pulley enough to bring the turntable to the correct speed. Figure 22-43 illustrates how this is done. The spring may be easily removed by holding the rotor to keep it from turning and pulling off the spring with a twisting motion. Install the new spring by pushing it on the shaft, and turning it as it is pushed on.

Another factor that must be considered in the conversion of a motor from 60 to 50 cycles is that the inductive reactance is lower at the lower frequency and more current will flow in the windings. This will result in an increase in temperature of the motor windings. Some motors may withstand this temperature increase without any damage, but others may break down in a short time because of insulation failure. It is recommended that only motors designed to operate on 50 or 60 cycles be used for such conversions.